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AN/BRN-7 COMPUTER PROGRAM SPECIFICATION. VOLUME IV. OMEGA PROCE--ETC(U)

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- [ ] This submittal applies to AN/BRN-7 (Submarine Ω) only.
- [ ] This submittal applies to AN/SRN-( ) (Hydrofoil Ω) only.
- [X] This submittal applies to both AN/BRN-7 and AN/SRN-( ).

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NORT 73-48

AN/BRN-7 COMPUTER PROGRAM SPECIFICATION

Volume IV

OMEGA PROCESSING SUBPROGRAM DESIGN

October 12, 1973

Approved by

G. W. Hauser
Director, Engineering
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Volume IV
of the
AN/BRN-7 OMEGA COMPUTER
PROGRAM SPECIFICATION

CONTENTS

SECTION 1

SCOPE

1.1 IDENTIFICATION

Volume I, Submarine OMEGA Computer Program Performance Specification, defines the functional requirements for the Submarine OMEGA Computer Program which is used by the AN/BRN-7 OMEGA Navigation Set. The Navigation Set and the OMEGA program together comprise the Submarine OMEGA Navigation System. The tape which defines the computer program is entitled AN/BRN-7 Navigation Program.

Volume II, Submarine OMEGA Computer Program Design Specification, allocates the functional requirements of Volume I to the computer routine and subprogram level.

This volume describes the subprogram designated as OMEGA Processing, which is composed of the following routines and their abbreviations which will be found in the listing.

Routine	Abbreviation
End of Burst	EB
Start of Slot	SS
End of Slot	ES
Start of Burst	SB

1.2 OMEGA PROCESSING SUBPROGRAM TASKS

1.2.1 Tasks

The following tasks are listed as functional requirements from Volume I.

a) Signal Input Timing: The maintenance of the synchronization of tasks to the OMEGA transmission pattern is referred to as signal input timing. Burst data must be accumulated, saved and processed with precise timing, the control of test inputs and the collection of both test and noise data during alternate slot intervals requires strict synchronization.

b) Antenna Switching Control: The Antenna Switching Matrix consists of a group of gates for each of the three Receiver Strips. The function of these gates is to control the signal inputs to the receiver strips. The purpose of the gate control is to permit enhancement of the characteristics of the selected signals. For instance, in measuring phase it is desirable to eliminate one loop of the orthogonal loop antenna, thereby reducing noise and increasing the signal-to-noise ratio. For test and calibration, it is desirable to eliminate antenna inputs entirely.

c) Bias, Scale Factor and Phase Shift Calculations: The receiver correlators may have a bias and there may be hardware-induced phase shifts. These anomalies, which could introduce error into the estimate of phase, will be removed by the procedures following. Also, the phase shifts introduced by the antenna and couplers are removed.

There are eight slots in the 10-second OMEGA cycle. Four are reserved for noise measurements, the other four for the test and calibration signals. For each transmission frequency there will be injected into the antenna switching matrices the following: Test (T), minus Test (-T), Test plus 90° (T+90), and minus Test plus 90° (-(T+90)). One of these four signals will be introduced at every other slot period. At the end of the 10-second cycle the Bias and Scale Factor calculations will be made, the known phase shifts removed and the results tested for credibility.

d) Noise Calculations: It is necessary to estimate system-external noise. The output will be used to determine credibility of the next two burst measurements on the pertinent frequency. If noise is high, then little weight is given these measurements. Conversely, if low, then the burst measurements are considered accurate.

This is not a linear estimate. If noise is above a criterion value it is amplified to assure credibility of next two bursts. If low and the last noise measurement was high, then the new value is sharply reduced to a reasonable level. If both previous and current value is low, then the new value of Q_t is a smoothed value of the old.

e) Phantom Calibration: In some cases the interaction of the hardware components produces a nontransient phase which must be detected (if it exists) on each frequency and rejected. This is done by a phase measurement during a slot interval then removing these spurious signals during burst-phase calculations.

f) Burst Phase Measurement: The phase sinusoids from the receiver will be processed by the procedure following to yield a phase representation in radians. The hardware phase shifts, correlator bias and scale factor, calculated elsewhere, will be removed here as will any phantom phase anomalies.

The variance of the phase angle which represents the credibility assigned to the incoming data will also be calculated.

g) Base Station Selection: The burst phase calculation will yield the first rough estimates of phase and signal variance from each station and on each frequency. However, the tracking filters track phase differences between two stations, the second of which has been designated as the base station. The computer program designates one of the four stations as the base station when its three frequency signal strength is largest.

1.2.2 Allocation of Tasks

The allocation of functional requirements from the Submarine OMEGA Computer Program Performance Specification (Volume I) is given below.

A review of the functional requirements listed and their interrelationship will aid in understanding the OMEGA Processing Subprogram.

Subprogram	Routine	Functional Requirement
OMEGA PROCESSING	END BURST	3.3.2 Signal Input Timing. Determination of $\Delta t\Omega$ for START SLOT routine. 3.3.7 Burst Phase Measurement.
	START SLOT	3.3.2 Signal Input Timing. Determination of $\Delta t\Omega$ for START SLOT routine.
	END SLOT	3.3.2 Signal Input Timing. Determination of $\Delta t\Omega$ for START BURST routine. 3.3.3 Antenna Switching Control. Portions relating to set-up for burst measurements. 3.3.4 Bias, Scale Factor and Phase Shift. 3.3.5 Noise Calculations. 3.3.6 Phantom Calibration.
	START BURST	3.3.2 Signal Input Timing. Collection of burst input data, and determination of $\Delta t\Omega$ for Combinational Filter. 3.3.8 Base Station Selection.

SECTION 2

APPLICABLE DOCUMENTS

a) Submarine OMEGA Computer Program Performance Specification (Volume I of the Submarine OMEGA Computer Program Specification).

Applicable Sections

3.1 Introduction
3.2 Functional Description
 3.2.5 Detailed System Operations
3.3 Detailed Functional Requirements
 3.3.2 Signal Input Timing
 3.3.3 Antenna Switching Control
 3.3.4 Bias, Scale Factor and Phase Shift
 3.3.5 Noise Calculations
 3.3.6 Phantom Calibration
 3.3.7 Burst Phase Measurement
 3.3.8 Base Station Selection

b) Submarine OMEGA Computer Program Design Specification (Volume II of the Submarine OMEGA Computer Program Specification).

c) NORT 71-41, NDC 1070 MACRO ASSEMBLER, MAY 1971

d) NORT 68-115A, Detailed Description of NDC 1070 Computer Instructions, Revision A, February 1970.

e) NORT 69-87A, NDC 1070 Flow Chart Program, User's Manual

SECTION 3

REQUIREMENTS

In order to understand the program description contained in the following pages, it is necessary that the reader will have become familiar with the associated functional requirements found in Volume I, Performance Specification, and with the subprogram allocation found in Volume II, Design Specification.

3.1 DETAILED DESCRIPTION

3.1.1 Reference Labels to Flow Diagrams

The code used to reference the particular block in the flow diagrams, Section 3.2, is as follows: The first number, preceded by a p, is the page number found in the upper right corner of the diagrams. This will be followed by a slash sign (/) to separate the page number from the block designator. The designator will either be a mnemonic label (e.g., TEST SYNC), a local label indicated by a dollar sign ($), or an integer. The two types of labels reference the particular information block, on the given page, to which the label is attached. The integer number, n, means that the referenced block is the n^{th} block from the top of the page; p8/3 would refer to page 8 and the third information designation down.

The label p1/$2+3 refers to page 1, and the 3rd information block after the label $ 2. p2/7,8,9 refers to page 2 and the 7th, 8th and 9th blocks.

3.1.2 Description

3.1.2.1 End of Burst

This is an OMEGA-task (see Volume II) which is initiated at the conclusion of the data collection period. There will be three station transmissions processed. End of Burst begins ideally at 0.1 second prior to the end of station transmissions.

Data received during the start burst and end burst intervals is corrupted by the rise and fall of signal waveform and by transients introduced by antenna and test selection commands. These are therefore waiting periods in which data is not used.

Data received during the burst interval is used to determine phase of the received signal.

Test and calibration data are received in the test slot. This will be used to improve accuracy of calculations made from burst measurement and to provide measurement of variance of phase measurements.

pl/END OF BURST

Set $\Delta t \Omega$ = 0.15 and set the next Ω-task as START SLOT. This is a basic function of each Ω-task; each must set up the transmission-dependent $\Delta t \Omega$ time for the next task.

pl/2

The accumulations of the time averaged values of sine Ø and cos Ø over the burst interval may be represented as:

$$X_m = \sum_{j=1}^{L} X_j$$

$$Y_m = \sum_{j=1}^{L} Y_j .$$

where L = 140, 160, 180 or 200 depending upon burst length. (one L count represents 0.005 second worth of data)

pl/3 + table

When the accumulation of burst data has been completed, the information in the summation registers is used in the burst computations. The set-up for slot time operations is also accomplished at this time. If a noise measurement is to be made during the upcoming slot time TNB is set to Noise and the antenna configuration is alternated between the A and B lobes (assuming the orthogonal loop antenna is used). If a test operation is to be performed, the appropriate one of the four test configurations is sent to the Switching Matrix (TNB set to Test).

pl/5

This is part of OMEGA processing initialization. No phase data calculations will be made without a noise measurement available or until a phantom measurement has been made.

p2/$ 30 through p2/$ 1 + 1

Calculate Δt_b = time span over which burst was measured and apply scale factor.

$$X_B' = X_m/A_x$$

$$Y_B' = Y_m/A_y$$

where A_x, A_y are calculated in the End of Slot routine, p9/$ 10.

Correct measurements for spurious phase signals and correlator bias.

$$\left.\begin{aligned} X_B &= X_B' - \Delta t_b X_{PA} \\ Y_B &= Y_B' - \Delta t_b Y_{PA} \end{aligned}\right\} \text{ If A lobe was used to receive signals}$$

or

$$\left.\begin{aligned} X_B &= X_B' - \Delta t_b X_{PB} \\ Y_B &= Y_B' - \Delta t_b Y_{PB} \end{aligned}\right\} \text{ If B lobe was used to receive signals}$$

where X_{PA}, Y_{PA}, X_{PB}, Y_{PB} are calculated in the End of Slot routine p11/$ 10.

p2/$ 1 + 2

Compute the phase angle ϕ_m and subtract ϕ_o, the phase shift introduced by the hardware, then add ϕ' which corresponds to either 0^o or 180^o depending upon whether the inverse or obverse antenna lobe was used.

$$\phi_m = \text{TAN}^{-1}\left(\frac{X_B}{Y_B}\right) - \phi_o + \phi'$$

Note on P2/$ 1 + 3 through p4/$ 5.

This portion will calculate $\sigma^2_{\phi_m}$ the computed variance of the phase angle measured at the burst level. To do this Q_m, the burst element of phase variance, is used together with Q_t, the noise measurement taken during a previous slot. This mathematical comparison of Q_t and Q_m yields $\sigma^2_{\phi_m}$ which

is a function of the signal-to-noise ratio and therefore a measure of the **trustworthiness** of the phase measurement obtained (ϕ_m).

p2/$ 1 + 3

$$Q_m = \frac{X_B^2 + Y_B^2}{\Delta t_b}$$

Computer program determines that station "i" is a usable station and that it has finished the third (and last) burst for the current 10-second broadcast cycle. The phrase usable station means a station not deselected by operator and not within 400 miles.

p3/$68

Sum Q_m values for station i.

Let $RH_i = Q_{mi}(10.2) \times Q_{mi}(13.6) \times Q_{mi}(11\text{-}1/3)$

This will be used for base-station selection in the Start of Burst Routine, P15/$ 3.

p3/$ 68 +2 to p4/$ 5

$$\sigma^2_{\phi_m} = \frac{Q_t\left(\Delta t_b - Q_m\right)}{2\,\Delta t_b\left(Q_m - Q_t\right)} + \frac{1}{4}\ \text{cec}^2$$

where Q_t calculated in End of Slot routine, p12/2.

Here, $1/4$ cec^2 is added to achieve a minimum value for $\sigma^2_{\phi_m}$. Δt_b = time span over which burst was measured.

At this point the program sequences to the tracking filter routine (see Vol V).

3.1.2.2 Start Slot

This is an OMEGA task that is executed at the start of the 0.1 second slot data collection period. This program clears the six sin/cos registers and monitors for a precision frequency generator failure.

p5/START OF SLOT

Set $\Delta t\Omega$ = 0.1 sec and designate next OMEGA task as End Slot.

p5/2 to P5/4

Test Description: Included as an integral part of the Precision Frequency Generator (PFG) is a Digital Phase Comparator which will detect an out-of-synchronization condition of the frequency divider network of the PFG. A BITE signal is generated when an out-of-sync condition is detected and is provided to the computer. The computer will sense this condition and generate a re-sync signal.

The program requirements for this test are as follows:

a) Test the PFG BITE signal discrete input at a rate no faster than once per 4 milliseconds.

b) If false no failure exists and return to program.

c) If true give a re-sync command (SET 000A) and restart the system.

p5/5

Due to switching transients and signal/noise corruption it is essential that the summation registers be cleared before the actual data accumulation. Test or noise measurements are then initiated which culminate at End Slot.

3.1.2.3 End of Slot

Completion of Slot Measurement

When either the test or noise measurements have been completed the measurements must be transferred from the summation registers to those used for computations. These transfers occur at End of Slot. The values generated during calibration will also be tested for reasonableness. If found to be unreasonable for any frequency, that frequency will not be used. Also at this time the antenna switching matrices are set for the reception of signals during the next burst.

The accumulations of the time averaged values of the sine and cosine of the signal (whether test signals or noise) may be represented as

$$X_m = \sum_{j=1}^{20} , X_j$$

$$Y_m = \sum_{j=1}^{20} , Y_j$$

p6/ END OF SLOT

Due to oscillator drift the synchronization of the computer program to that of the transmitted pattern could eventually wander off far enough to cause an out-of-synch condition. However, the oscillator drift, $\dot{t}_o$, is a state variable in the combinational filter. By integrating $\dot{t}_o$ this drift in time is detected, and compensation is provided here by a ±5 millisecond interrupt increment to the program timing counter.

The calculation performed in the combinational filter is

$$\text{Time increase} = \int_o^t \dot{t}_o \, dt$$

where the zero lower limit is reinitialized whenever the summation exceeds + or -5 milliseconds and time is corrected for oscillator drift.

p6/2

Set $\Delta t\Omega$ = 0.15 and select START BURST as next Ω-task.

p6/3

The six sine-cosine data words are read from DMA.

p6/$ 3 + 1

Use the common subroutine BEARING to:

Calculate ψ_B, the bearing to the station selected (north to heading vector CW positive)

$$\psi_B = -\tan^{-1}\left(\frac{-D_i \cdot R_2}{D_i \cdot R_3}\right)$$

where R_i are the system computation axes:

$\hat{R}_1$ is the local vertical,

$\hat{R}_3$ is the reference azimuth axis

$\hat{R}_2$ is $\hat{R}_3 \times \hat{R}_1$

$\hat{D}_i$ are vectors describing station locations on earth's surfaces using earth axes as reference frame.

p6/$ 3 + 2 through p7/3

If orthogonal loop antenna is in use then

Calculate θ_{BR} the relative bearing to a selected point measured from the effective A-loop antenna center line to bearing CW positive.

$$\theta_{BR} = \psi_B - \psi_A - 180^\circ - \theta_p$$

where ψ_A is submarine heading measured north to the centerline clockwise (CW) positive.

θ_p is the system azimuth angle between north and R_3 CCW positive.

Referring to Figure

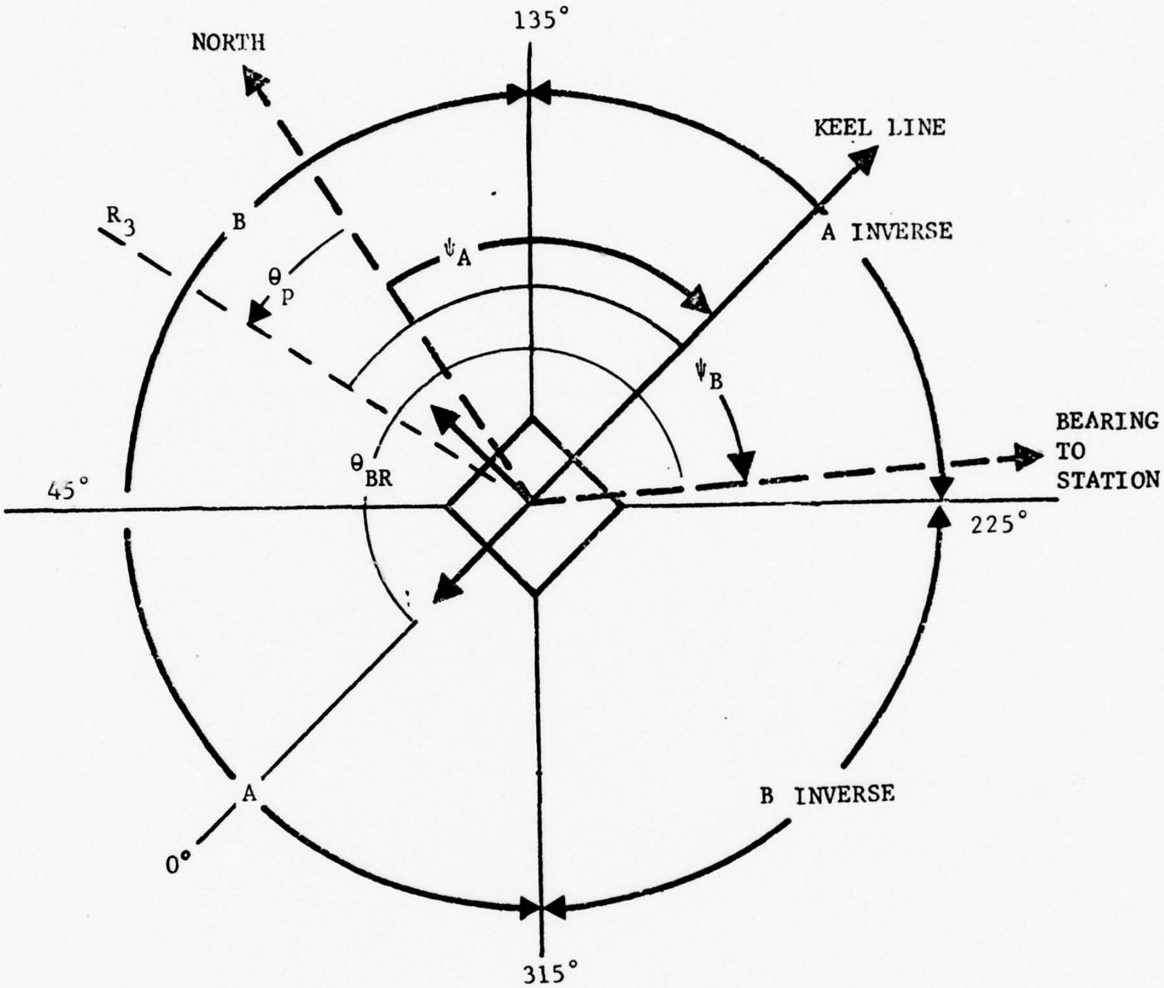
If $315^\circ < \theta_{BR} < 45^\circ$, set RX(A) = true, set Ø' = 0.

If $225^\circ < \theta_{BR} < 315^\circ$, set RX(B) = true and set Ø' = 180°.

If $135^\circ < \theta_{BR} < 225^\circ$, set RX(A) = true and set Ø' = 180°.

If $45^\circ < \theta_{BR} < 135^\circ$, set RX(B) = true and set Ø' = 0°.

Where Ø' will invert the phase in the Burst Processing equations and RX(A) and RX(B) markers will command the antenna switching matrix via DMA I/O. Ø' is a marker which is saved at p7/$ 2 + 1. Note that 45° is added to θ_{BR} so that the 90° and 180° BIT locations can be used for switching control.



$$\theta_{BR} = \psi_B - \psi_A - 180° - \theta_p$$

FOUR-LOBE LOOP ANTENNA CONFIGURATIONS FOR RANGES OF θ_{BR}

p7/$ 52

Then is FLOAT marker = true?
If so, then RX(A) = true

An addition of 45° is added to θ_{BR} to use the 180° BIT to set Ø'.

p7/$ 2

Antenna Selection is output to switching matrix in receiver.

p7/$ 2 + 1

Refer to p6/$ 3 + 2 description.

p8/2,3

The remaining calculations will be either noise or calibration calculations. If p7/3 determines that the previous slot data is from noise then sequencing branches to p11/NOT CALIB where, unless calibration calculations have not as yet been made, the noise data is processed. To promote a smooth flow diagram description, it is assumed that the previous slot was the fourth calibration slot. If not sequencing branches to p11/NOT FOURTH CALIBRATION and exits.

p8/4

The following procedure is indicated for one channel only. It must be done three times in all (once for each frequency) in each 10-second OMEGA cycle.

At the test slot time determined by station counter numbers 0,2,4,6 obtain the sine and cosine measurements of the injected test signals.

$$X_{ci} = X_m/\Delta t_c$$

$$Y_{ci} = Y_m/\Delta t_c$$

$$\Delta t_c = 0.1 \text{ sec}$$

The results are as follows:

X_{c1}, Y_{c1}	Sine (T)	, cosine (T)
X_{c2}, Y_{c2}	Sine (-T)	, cosine (-T)
X_{c3}, Y_{c3}	Sine (T+90)	, cosine (T + 90)
X_{c4}, Y_{c4}	Sine (-(T+90))	, cosine (-(T+90))

p8/5

As stated, it is assumed that the data is the 4th calibration slot in the 10-second OMEGA pattern. If it were not then sequencing branches to p11/ NOT FOURTH ITERATION where the END OF SLOT routine is exited.

p8/$ 7 through p9/2

On each of the three frequencies calculate the bias of the X and Y channels and check for credibility.

$$B_X = (X_{c1} + X_{c2} + X_{c3} + X_{c4})/0.1$$

$$B_Y = (Y_{c1} + Y_{c2} + Y_{c3} + Y_{c4})/0.1$$

Is $\left| B_X \right| < N_B$? $N_B = 250$ counts

If not, indicate SYSTEM FAIL = true and continue;

If so, continue

Is $\left| B_Y \right| < N_B$?

If not, indicate SYSTEM FAIL = true and continue;

If so, continue.

p9/$ 10 through p9/$ 21 + 1

On each of the three frequencies of the X and Y channels and check for credibility.

$$A_X = 10 \left[(X_{c1} - X_{c2})^2 + (X_{c3} - X_{c4})^2 \right]^{\frac{1}{2}}$$

$$A_Y = 10 \left[(Y_{c1} - Y_{c2})^2 + (Y_{c3} - Y_{c4})^2 \right]^{\frac{1}{2}}$$

Test: Is $\left| A_X - A_{CALIB} \right| < N_A$? $N_A = 500$ counts

$A_{CALIB} = 1600$ counts

If not, indicate SYSTEM FAIL = true and continue;

If so, continue.

Test: Is $\left| A_Y - A_{CALIB} \right| < N_A$?

If not, indicate SYSTEM FAIL = true and Exit;

If so, -- Exit.

p10/$ 8 through p10/8

Although ϕ_o is not used in phase difference navigation it is calculated and saved.

At end of last test slot, and noting that Y_{c4} and Y_{c3} are, by trigonometric identity, functions of the sine; and similarly that X_{c3} and X_{c4} are functions of the cosine:

$$\phi_o = \tan^{-1}\left[\frac{X_{c1} - X_{c2} + Y_{c4} - Y_{c3}}{X_{c3} - X_{c4} + Y_{c1} - Y_{c2}}\right] + \phi_{CALIB}$$

where ϕ_{CALIB} is a constant whose value is a combination of values dependent upon the phase shift characteristics of the couplers and antenna used:

$$\phi_{CALIB} = \phi_{OMEGA\ COUPLER} + \begin{cases} \phi_{FLOATER/ACU1441} \\ \quad \text{or} \\ \phi_{LOOP\ ANT/ACU1441} \end{cases}$$

The following table summarizes the values.

		PHI-ZERO-FLOATER	PHI-ZERO-LOOP
	$\phi_{OMEGA\ COUP}$	$\phi_{FLOAT/ACU1441}$	$\phi_{LOOP/ACU1441}$
Frequency 10.2	1 cec	-90 cec	-17.8 cec
13.6	1.5 cec	18 cec	9.8 cec
11-1/3	1.5 cec	2 cec	-5.7 cec

p11/NOT FOURTH ITERATION

This is the exit as explained in description of p8/2,3.

p11/NOT CALIB to p11/$ 9

This loop ensures that noise computations will not be made until after first calibration computations.

p11/$ 10

Take sine and cosine values of incoming signals from receiver taken over a slot period (between bursts) and remove scale factors.

$$X_N' = X_m/A_x$$

$$Y_N' = Y_m/A_y$$

Following this is a simple filtering device which will track the phase phantom. K_p is of the value 0.001. Since the phantom is constant, this simple filtering device suffices. The phantom measurement will be calculated as indicated below for each frequency.

For X channel (sine function)

Either: $X_{PA} = K_{p1}X_N' + X_{PA_{(i-1)}} \quad K_{p2}$; when A Lobe selected

Or: $X_{PB} = K_{p1}X_N' + X_{PB_{(i-1)}} \quad K_{p2}$; when B Lobe selected

For Y channel (cosine function)

Either: $Y_{PA} = K_{p1}Y_N' + Y_{PA_{(i-1)}} \quad K_{p2}$; when A Lobe selected

$X_{PB} = K_{p1}X_N' + Y_{PB_{(i-1)}} \quad K_{p2}$; when B Lobe selected

where $K_{p1} = .01$ (through $K_p = .001$, $K_{p1} = .01$ reflects implicit division by $\Delta t = .1$)

$K_{p2} = .999$

Form $(X_N')^2$ and $(Y_N')^2$

p12/2

Obtain rough measurement of noise (Q_t').

$$Q_t' = \frac{\left(X_N'\right)^2 + \left(Y_N'\right)^2}{\Delta t_N}$$

p12/4 through P13/$ 30 + 1

Now test Q_t' to see whether larger than criterion value $Q_{to} = 0.05$

<u>If so</u>, then amplify this number. This will later deemphasize credibility of next two burst measurements due to excessively high noise.

$$Q_t = 9\,Q_t' - 0.4$$

Save and Exit

<u>If not</u>, (if $Q_t' < 0.05$) then:

Test old value to see if it was reasonable.

is $Q_t < Q_{to}$

<u>If so</u>, then smooth by using old value of Q plus fraction of Q.

$$Q_t = Q_t + K_Q\,(Q_t' - Q_t) \quad \text{where } K_Q = 0.05$$

Save and Exit.

<u>If not</u>, then reduce sharply to reasonable level.

Let $Q_t = 0.025$

And $Q_t = Q_t + K_Q\,(Q_t' - Q_t)$

Save and Exit.

3.1.2.4 Start of Burst

The period represented by this task is primarily for the purpose of data collection. This leaves the program free for other calculations. The only two pattern-related tasks are register clearing for data collection and

calculation of $\Delta t\Omega$ for next OMEGA task. However, it is also convenient to do base station selection at this time.

p14/START OF BURST

This sequence combines the calculations for $\Delta t\Omega$ with the clearing of the registers. $\Delta t\Omega$ must be extracted from a table of values due to the dissymmetry of the burst lengths in the OMEGA pattern.

p14/5 to P15/$ 3

This sequence prevents the selection of a base station before enough data has been collected, and limits the selection to once per 10 seconds.

p15/$ 3

The H bursts are computed in the tracking filter routine, Station A is selected as base in the event that none are available; a programming convenience. Sequencing branches here to p17/$5 where the H burst pointer is incremented then returns to P15/$ 4.

p16/1,2,3,4

If the station has been deselected by the operator and the station is not the base station then the H burst pointer is incremnted (p17/$5) and the loop is reentered. If it is the base station (and deselected) then the NEED BASE marker is set, H burst incremented and the loop reentered.

p16/5,6,7

If the station has been selected then the distance to the station is computed via the common subroutine THETA 1. If the station is less than 400 miles away the H burst pointer is incremented and the loop reentered.

If greater than 400 miles then continue.

p17/$ 41,2,3

Obtain and save maximum calculated H burst. This will eventually be used to compare with that of existing base station H burst value.

p17/$5 + 1

After the H burst values from all stations have been tested the NEED BASE marker is checked. If a base station is needed then that operational station with maximum H burst value will be used, the RESET TF and START markers to the tracking filters are set true and the NEED BASE marker is reset.

If a base station is not needed then the following test is performed to determine if the maximum H burst calculated is significantly greater than that of the present base station to warrant the trouble of a change of base.

If $SRH_i = SRH_{base} \times 1.1 + HYSTERESIS$

Then designate station i as new base station,
BASE Marker = i
Set RESET marker 0 to tracking filters,
Wait 10 seconds and set START marker 0 to tracking filters.

Otherwise continue with current base station.

In the above, HYSTERESIS is a term which may be used when operating in an area where all OMEGA transmissions are weak. Current value of HYSTERESIS is zero.

3.2 OMEGA PROCESSING FLOW DIAGRAMS

The OMEGA Processing Subprogram flow diagrams are presented on the following pages.

PAGE 0001

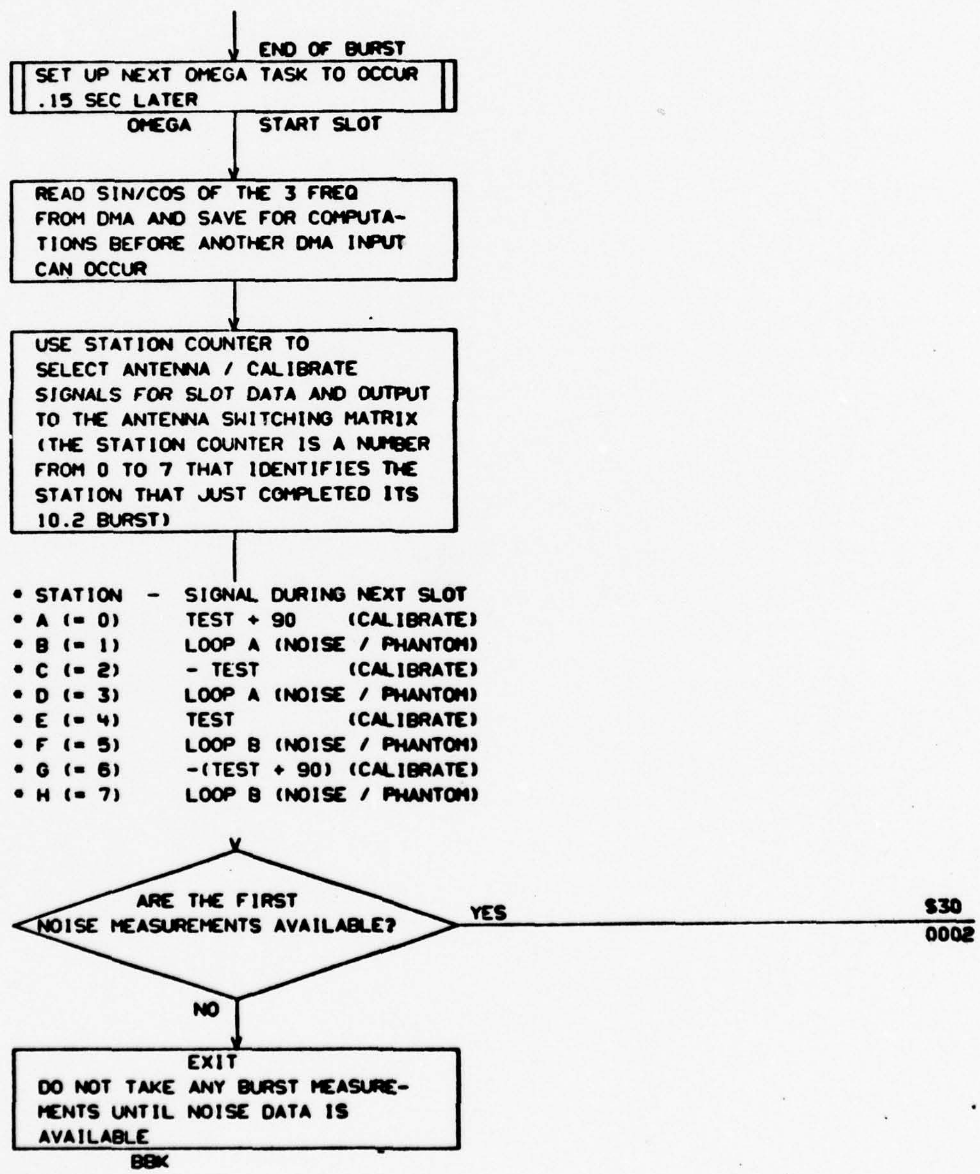
*

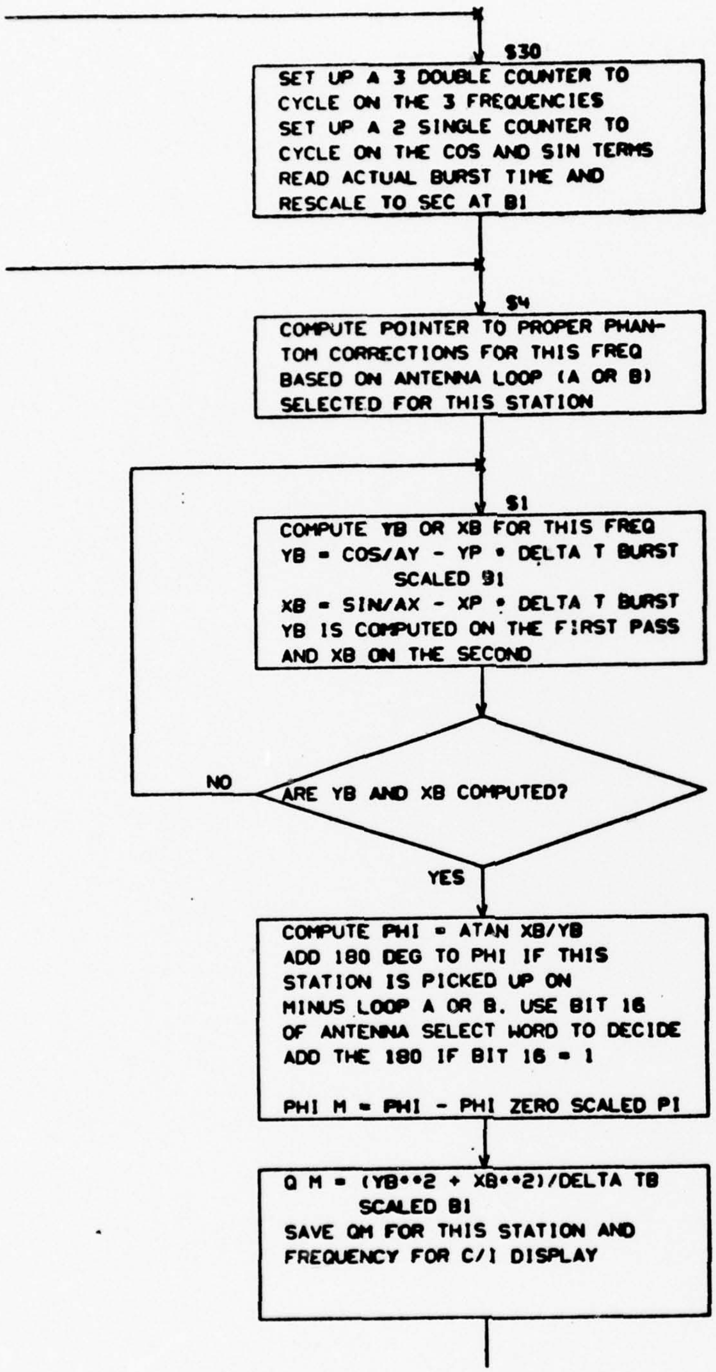
* END OF BURST

*

* THIS IS AN OMEGA TASK THAT IS EXECUTED AT THE CONCLUSION OF
* THE STATION BURST DATA COLLECTION PERIOD WHICH ENDS .1 SEC
* BEFORE THE ACTUAL STATION BURST ENDS. THIS ROUTINE SELECTS
* THE PROPER ANTENNA / CALIBRATE SIGNALS FOR THE SLOT MEASURE-
* MENT AND COMPUTES THE PHASE AND PHASE VARIANCE OF THE STATION
* BURST. IT EXITS DIRECTLY TO THE TRACKING FILTER PROGRAM.

*




S30
SET UP A 3 DOUBLE COUNTER TO CYCLE ON THE 3 FREQUENCIES
SET UP A 2 SINGLE COUNTER TO CYCLE ON THE COS AND SIN TERMS
READ ACTUAL BURST TIME AND RESCALE TO SEC AT B1
S4
COMPUTE POINTER TO PROPER PHANTOM CORRECTIONS FOR THIS FREQ BASED ON ANTENNA LOOP (A OR B) SELECTED FOR THIS STATION
S1
COMPUTE YB OR XB FOR THIS FREQ
YB = COS/AY - YP * DELTA T BURST SCALED B1
XB = SIN/AX - XP * DELTA T BURST
YB IS COMPUTED ON THE FIRST PASS AND XB ON THE SECOND
ARE YB AND XB COMPUTED?
NO
YES
COMPUTE PHI = ATAN XB/YB
ADD 180 DEG TO PHI IF THIS STATION IS PICKED UP ON MINUS LOOP A OR B. USE BIT 16 OF ANTENNA SELECT WORD TO DECIDE
ADD THE 180 IF BIT 16 = 1
PHI M = PHI - PHI ZERO SCALED PI
Q M = (YB**2 + XB**2)/DELTA TB SCALED B1
SAVE QM FOR THIS STATION AND FREQUENCY FOR C/I DISPLAY

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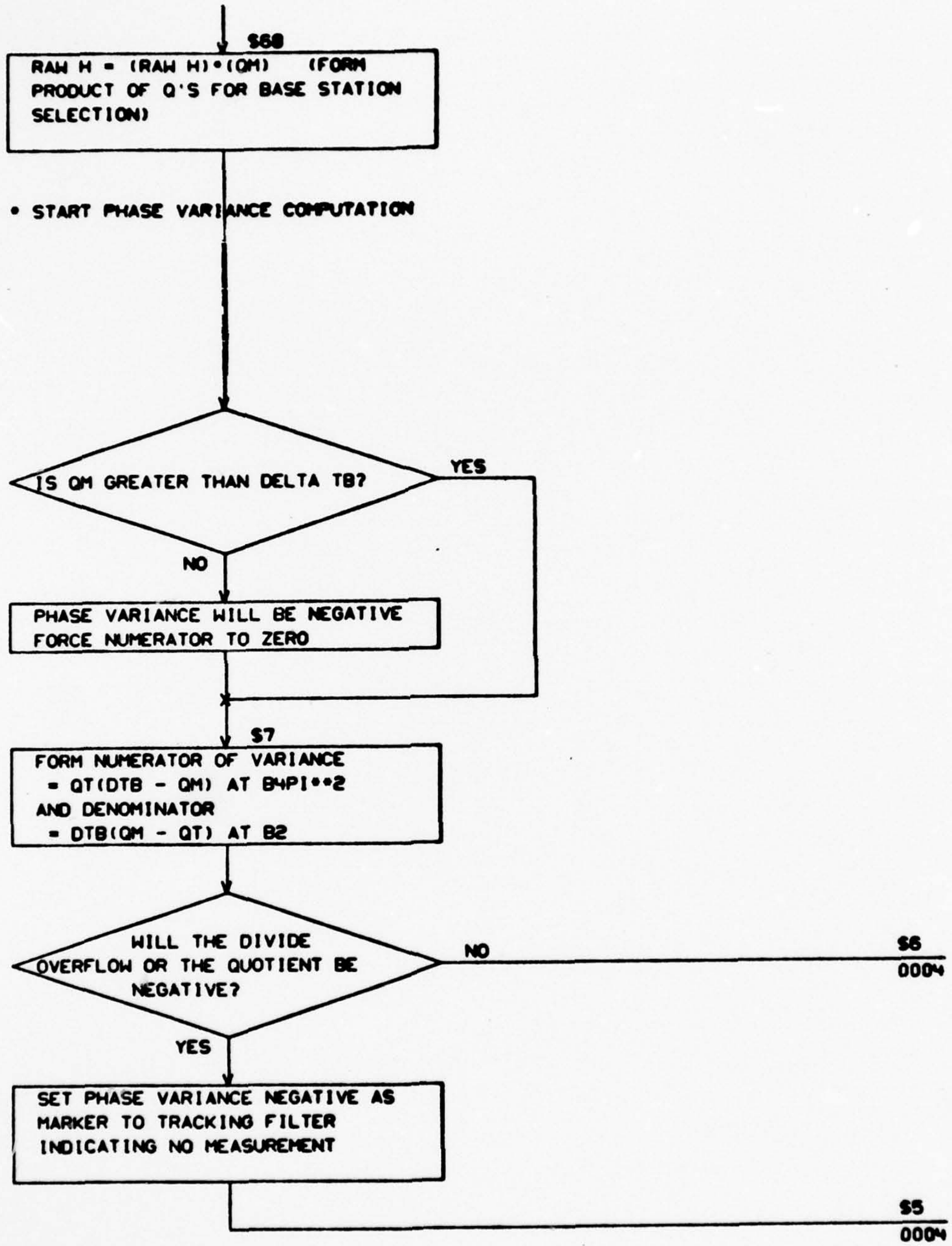
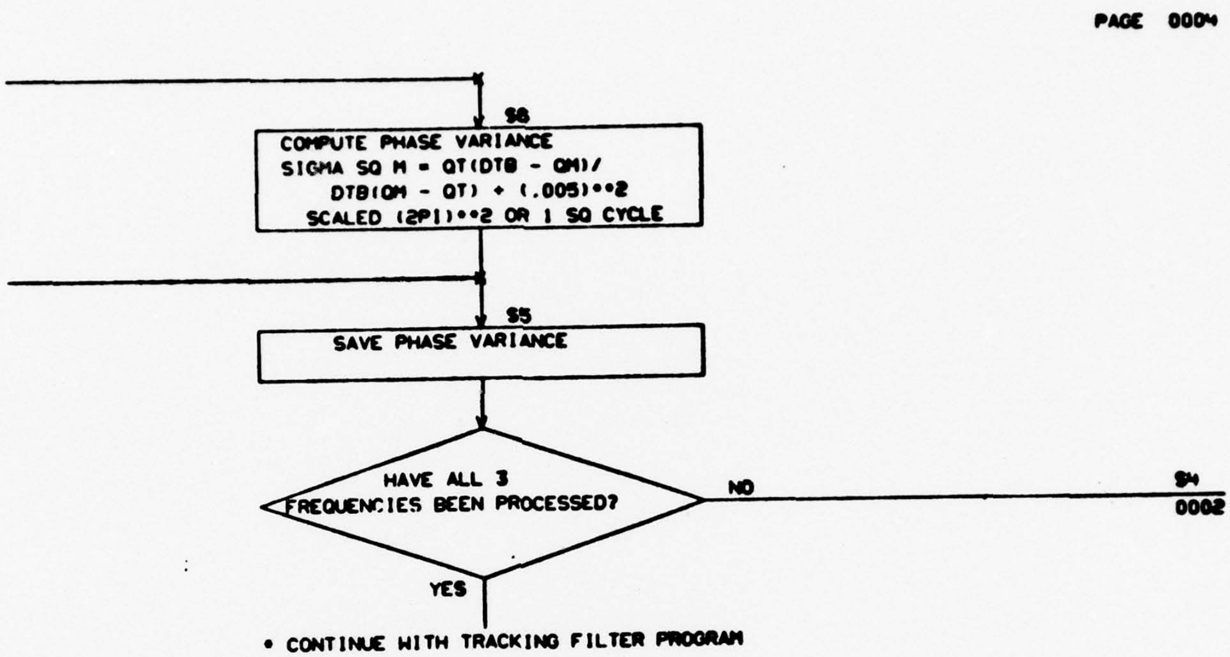
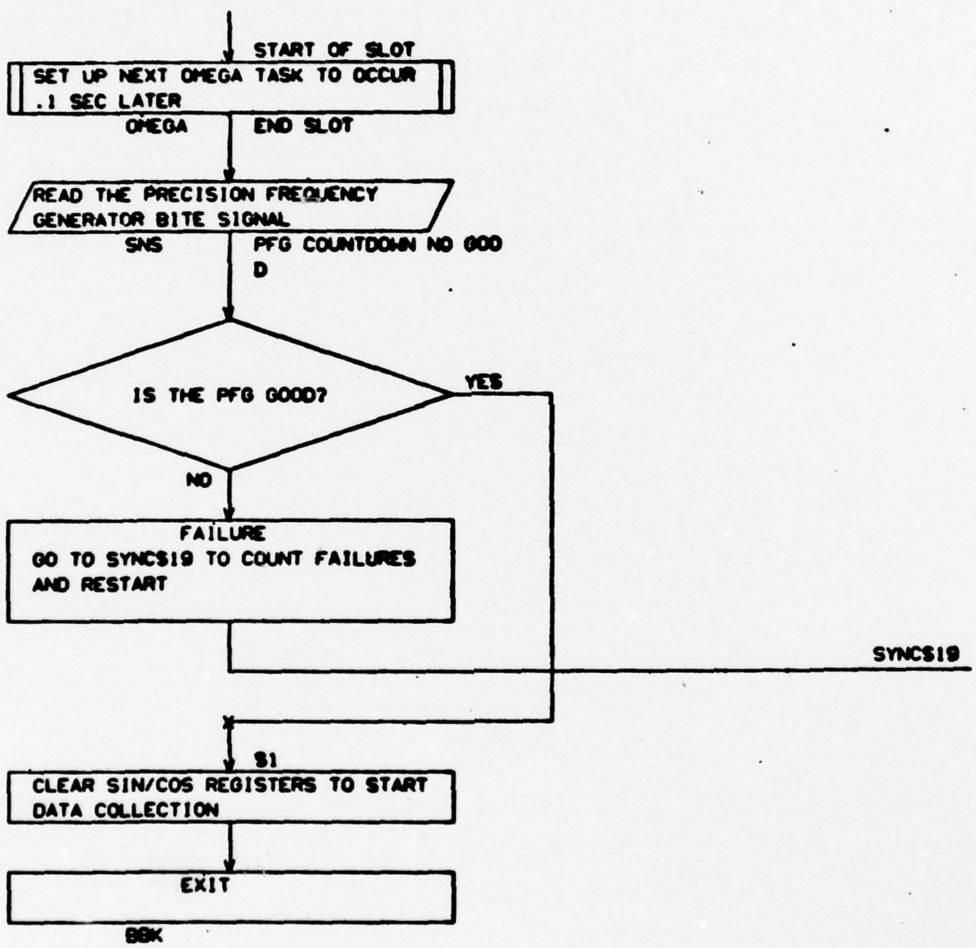

S6B
RAW H = (RAW H)*(QM) (FORM PRODUCT OF Q'S FOR BASE STATION SELECTION)
• START PHASE VARIANCE COMPUTATION
IS QM GREATER THAN DELTA TB?
YES
NO
PHASE VARIANCE WILL BE NEGATIVE FORCE NUMERATOR TO ZERO
S7
FORM NUMERATOR OF VARIANCE = QT(DTB - QM) AT B4PI**2 AND DENOMINATOR = DTB(QM - QT) AT B2
WILL THE DIVIDE OVERFLOW OR THE QUOTIENT BE NEGATIVE?
NO
S6
0004
YES
SET PHASE VARIANCE NEGATIVE AS MARKER TO TRACKING FILTER INDICATING NO MEASUREMENT
S5
0004


PAGE 0004
S8
COMPUTE PHASE VARIANCE
SIGMA SQ M = QT(DTB - QM)/
DTB(QM - QT) + (.005)**2
SCALED (2PI)**2 OR 1 SQ CYCLE
S5
SAVE PHASE VARIANCE
HAVE ALL 3
FREQUENCIES BEEN PROCESSED?
NO
S4
0002
YES
• CONTINUE WITH TRACKING FILTER PROGRAM

```
*                    START SLOT
*
* THIS IS AN OMEGA TASK THAT IS EXECUTED AT THE START OF
* THE .1 SECOND SLOT DATA COLLECTION PERIOD.  THIS PROGRAM
* CLEARS THE 6 SIN/COS REGISTERS AND MONITORS FOR A
* PRECISION FREQUENCY GENERATOR FAILURE
*
```



* END OF SLOT
*
* THIS IS AN OMEGA TASK THAT IS EXECUTED AT THE CONCLUSION OF
* THE SLOT .1 SECOND DATA COLLECTION PERIOD WHICH SHOULD BE
* THE EXACT CENTER OF THE SLOT. THIS ROUTINE PERFORMS ANTENNA
* SELECT FOR THE STATION BURSTS, COMPUTES SCALE FACTORS AND
* MAKES NOISE AND PHANTOM MEASUREMENTS.
*

END OF SLOT

CORRECT TIME FOR OSCILLATOR
DRIFT AS CALIBRATED BY KALMAN
TIME = TIME + TIME INCREMENT
TIME INCREMENT = 0
TIME INCREMENT WILL CONTAIN
+ OR - 5 MILLISEC WHENEVER THE
INTEGRAL OF T ZERO DOT SUMS TO 5
MILLISEC (PERFORMED IN KALMAN)

SET UP NEXT OMEGA TASK TO OCCUR
.15 SEC LATER

OMEGA START BURST

* NOTE - THE NEXT TASK WILL OCCUR .145
* OR .155 SEC LATER WHENEVER
* THERE IS A TIME CORRECTION

READ SLOT SIN/COS DATA BEFORE
NEXT DMA UPDATE
SET UP 3 COUNTER TO CYCLE
ANTENNA SELECT FOR 3 FREQ

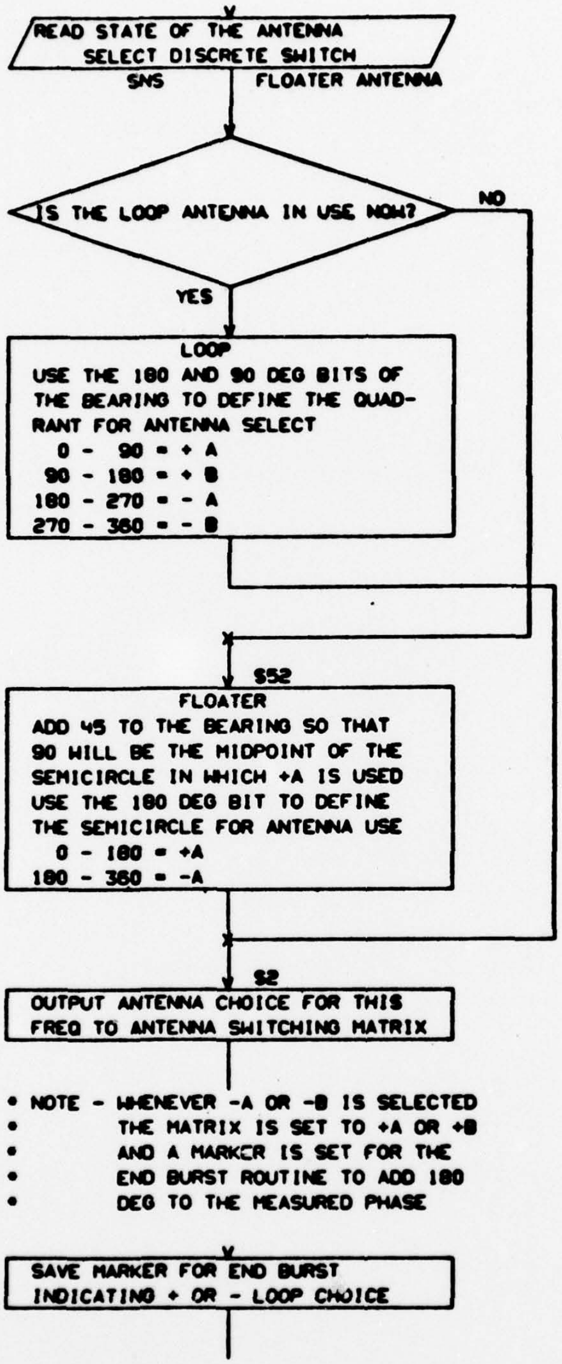
S3

USE STATION COUNTER AND FREQ TO
DETERMINE NEXT STATION TO
TRANSMIT THIS FREQ

COMPUTE RELATIVE BEARING FROM
R3 AXIS TO STATION (CW)

BSV BEARING

BEARING FROM +A LOOP TO STATION
= REL BEARING - THETA P - PSI A
- 180 DEG
ADD 45 SO THAT 45 WILL BE MID-
POINT OF QUADRANT IN WHICH THE
+A LOOP IS SELECTED


READ STATE OF THE ANTENNA SELECT DISCRETE SWITCH
SNS
FLOATER ANTENNA
IS THE LOOP ANTENNA IN USE NOW?
NO
YES
LOOP
USE THE 180 AND 90 DEG BITS OF THE BEARING TO DEFINE THE QUAD-RANT FOR ANTENNA SELECT
0 - 90 = + A
90 - 180 = + B
180 - 270 = - A
270 - 360 = - B
S52
FLOATER
ADD 45 TO THE BEARING SO THAT 90 WILL BE THE MIDPOINT OF THE SEMICIRCLE IN WHICH +A IS USED
USE THE 180 DEG BIT TO DEFINE THE SEMICIRCLE FOR ANTENNA USE
0 - 180 = +A
180 - 360 = -A
S2
OUTPUT ANTENNA CHOICE FOR THIS FREQ TO ANTENNA SWITCHING MATRIX
* NOTE - WHENEVER -A OR -B IS SELECTED
* THE MATRIX IS SET TO +A OR +B
* AND A MARKER IS SET FOR THE
* END BURST ROUTINE TO ADD 180
* DEG TO THE MEASURED PHASE
SAVE MARKER FOR END BURST INDICATING + OR - LOOP CHOICE

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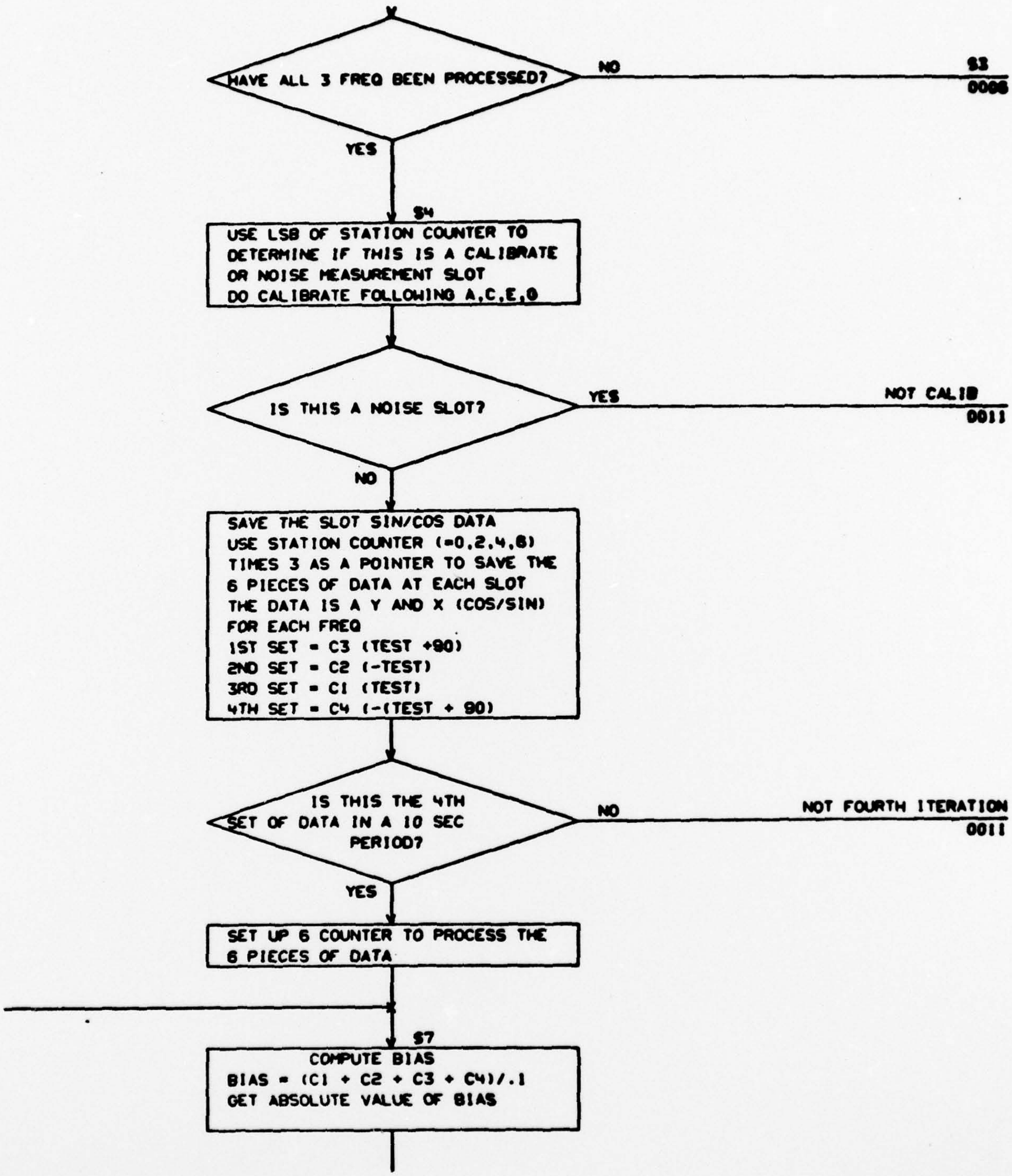
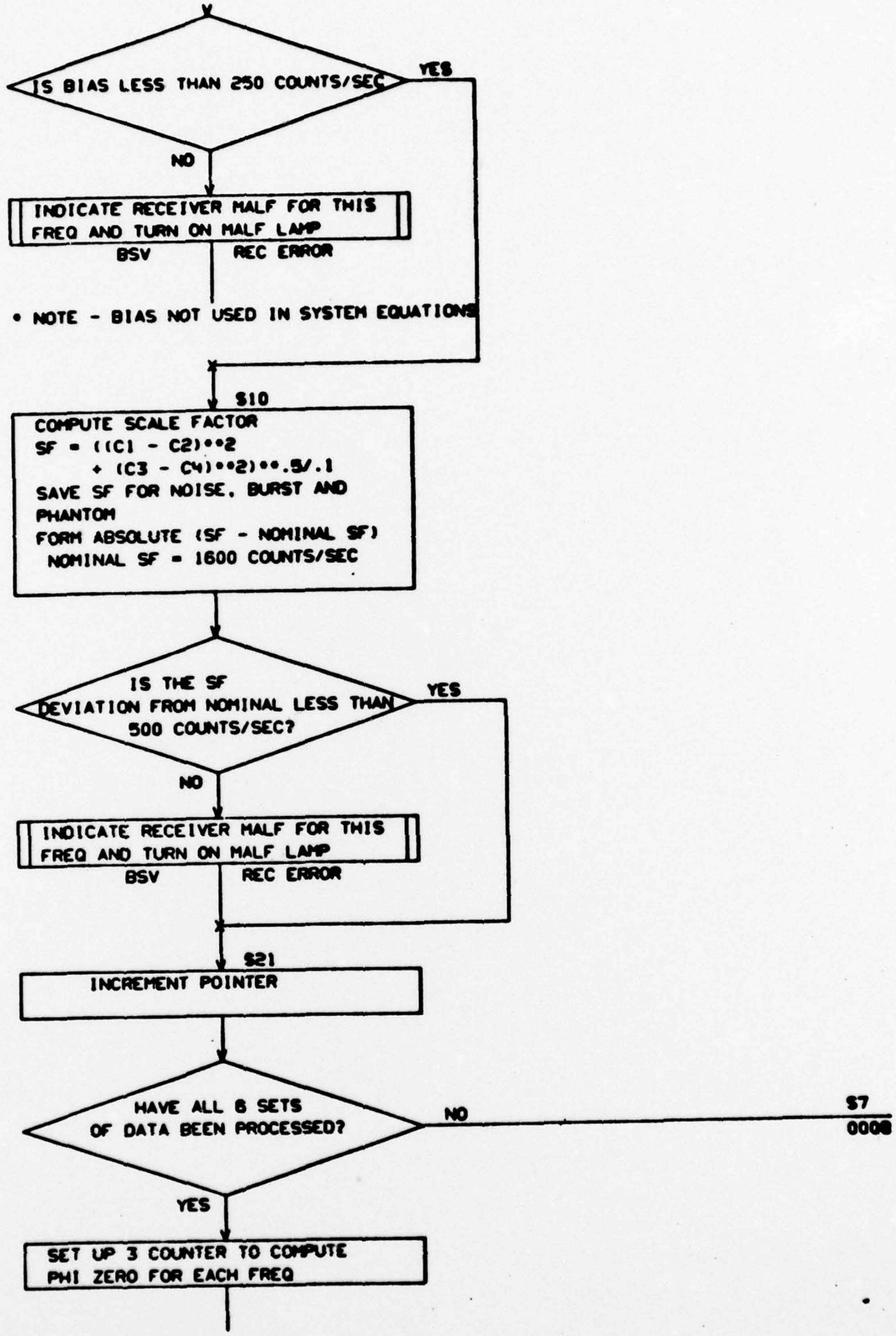
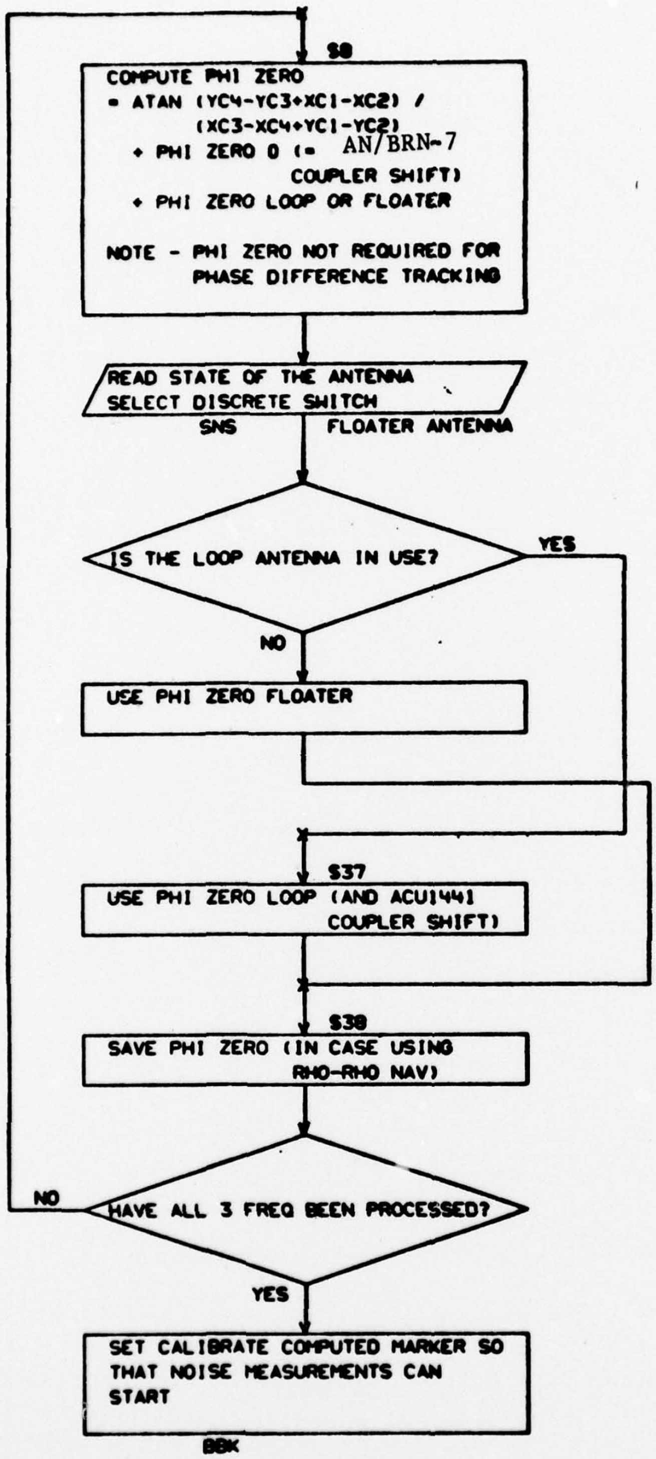
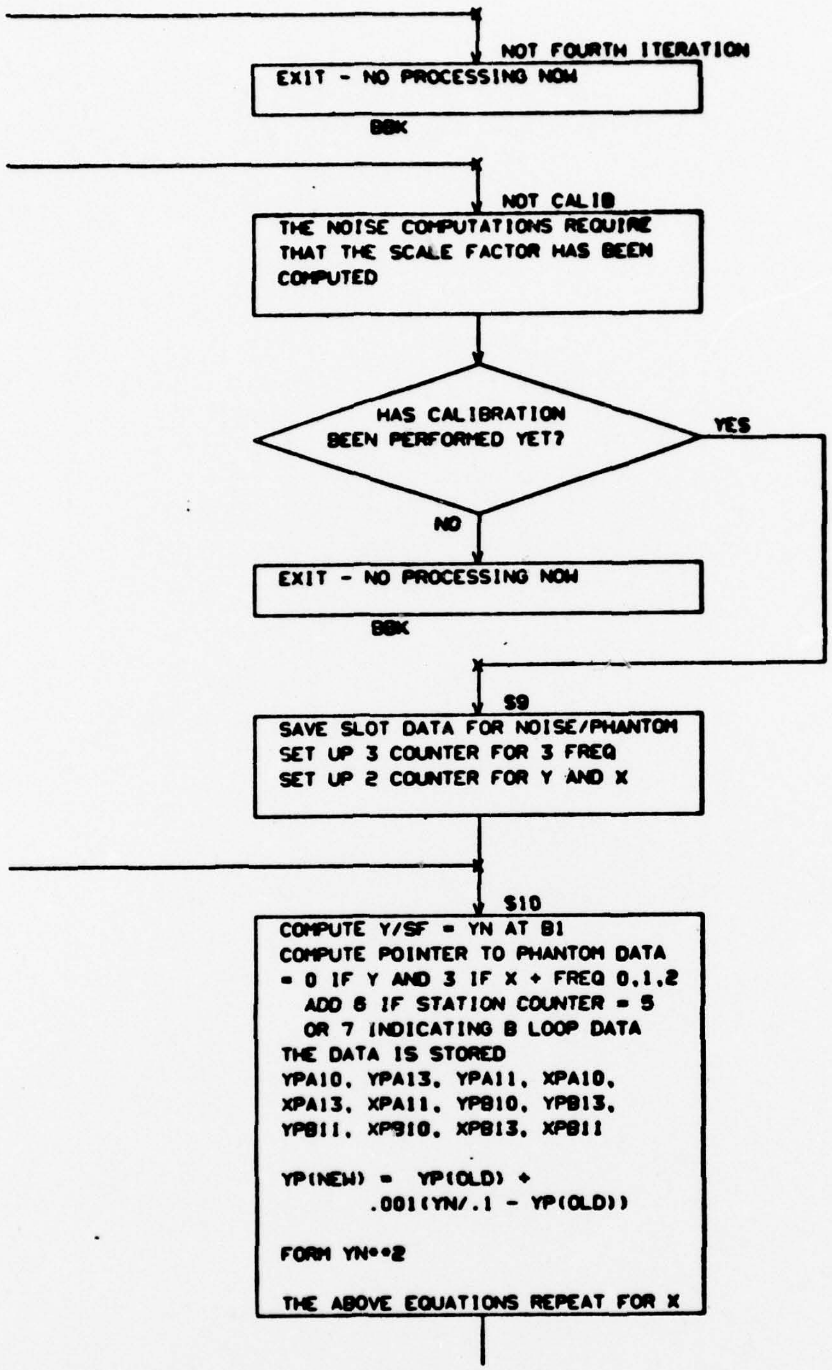
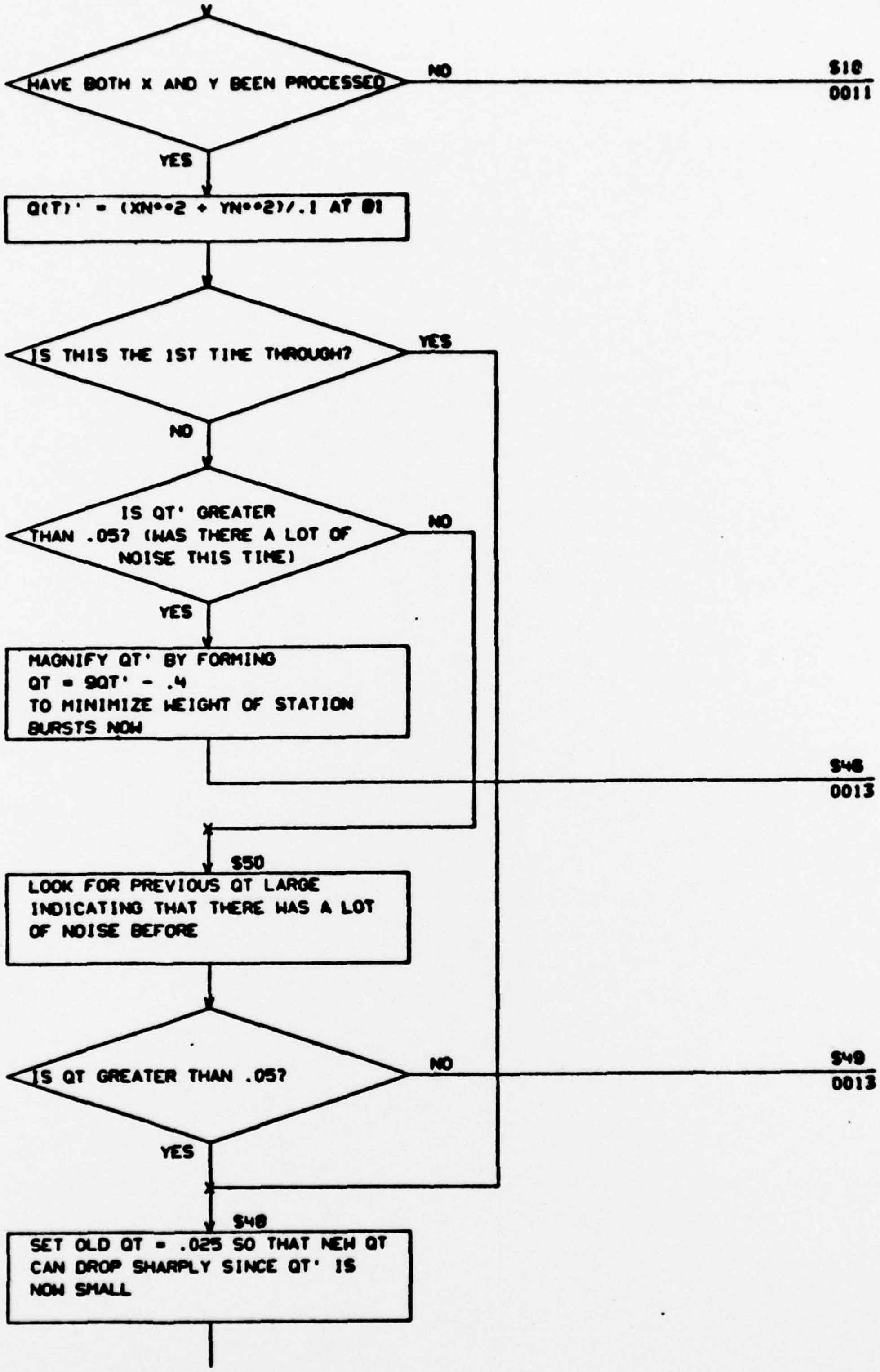

HAVE ALL 3 FREQ BEEN PROCESSED?
NO
$3
0006
YES
$4
USE LSB OF STATION COUNTER TO
DETERMINE IF THIS IS A CALIBRATE
OR NOISE MEASUREMENT SLOT
DO CALIBRATE FOLLOWING A,C,E,G
IS THIS A NOISE SLOT?
YES
NOT CALIB
0011
NO
SAVE THE SLOT SIN/COS DATA
USE STATION COUNTER (=0,2,4,6)
TIMES 3 AS A POINTER TO SAVE THE
6 PIECES OF DATA AT EACH SLOT
THE DATA IS A Y AND X (COS/SIN)
FOR EACH FREQ
1ST SET = C3 (TEST +90)
2ND SET = C2 (-TEST)
3RD SET = C1 (TEST)
4TH SET = C4 (-(TEST + 90)
IS THIS THE 4TH
SET OF DATA IN A 10 SEC
PERIOD?
NO
NOT FOURTH ITERATION
0011
YES
SET UP 6 COUNTER TO PROCESS THE
6 PIECES OF DATA
$7
COMPUTE BIAS
BIAS = (C1 + C2 + C3 + C4)/.1
GET ABSOLUTE VALUE OF BIAS


IS BIAS LESS THAN 250 COUNTS/SEC
YES
NO
INDICATE RECEIVER MALF FOR THIS FREQ AND TURN ON MALF LAMP
BSV
REC ERROR
• NOTE - BIAS NOT USED IN SYSTEM EQUATIONS
S10
COMPUTE SCALE FACTOR
SF = ((C1 - C2)**2
+ (C3 - C4)**2)**.5/.1
SAVE SF FOR NOISE, BURST AND PHANTOM
FORM ABSOLUTE (SF - NOMINAL SF)
NOMINAL SF = 1600 COUNTS/SEC
IS THE SF DEVIATION FROM NOMINAL LESS THAN 500 COUNTS/SEC?
YES
NO
INDICATE RECEIVER MALF FOR THIS FREQ AND TURN ON MALF LAMP
BSV
REC ERROR
S21
INCREMENT POINTER
HAVE ALL 8 SETS OF DATA BEEN PROCESSED?
NO
S7
0008
YES
SET UP 3 COUNTER TO COMPUTE PHI ZERO FOR EACH FREQ


S8
COMPUTE PHI ZERO
= ATAN (YC4-YC3+XC1-XC2) /
(XC3-XC4+YC1-YC2)
+ PHI ZERO 0 (= AN/BRN-7
COUPLER SHIFT)
+ PHI ZERO LOOP OR FLOATER
NOTE - PHI ZERO NOT REQUIRED FOR
PHASE DIFFERENCE TRACKING
READ STATE OF THE ANTENNA
SELECT DISCRETE SWITCH
SNS
FLOATER ANTENNA
IS THE LOOP ANTENNA IN USE?
YES
NO
USE PHI ZERO FLOATER
S37
USE PHI ZERO LOOP (AND ACU144)
COUPLER SHIFT)
S38
SAVE PHI ZERO (IN CASE USING
RHO-RHO NAV)
NO
HAVE ALL 3 FREQ BEEN PROCESSED?
YES
SET CALIBRATE COMPUTED MARKER SO
THAT NOISE MEASUREMENTS CAN
START
BBK


NOT FOURTH ITERATION
EXIT - NO PROCESSING NOW
BBK
NOT CALIB
THE NOISE COMPUTATIONS REQUIRE
THAT THE SCALE FACTOR HAS BEEN
COMPUTED
HAS CALIBRATION
BEEN PERFORMED YET?
YES
NO
EXIT - NO PROCESSING NOW
BBK
S9
SAVE SLOT DATA FOR NOISE/PHANTOM
SET UP 3 COUNTER FOR 3 FREQ
SET UP 2 COUNTER FOR Y AND X
S10
COMPUTE Y/SF = YN AT B1
COMPUTE POINTER TO PHANTOM DATA
= 0 IF Y AND 3 IF X + FREQ 0,1,2
ADD 6 IF STATION COUNTER = 5
OR 7 INDICATING B LOOP DATA
THE DATA IS STORED
YPA10, YPA13, YPA11, XPA10,
XPA13, XPA11, YPB10, YPB13,
YPB11, XPB10, XPB13, XPB11
YP(NEW) = YP(OLD) +
.001(YN/.1 - YP(OLD))
FORM YN**2
THE ABOVE EQUATIONS REPEAT FOR X


HAVE BOTH X AND Y BEEN PROCESSED
NO
S10
0011
YES
Q(T)' = (XN**2 + YN**2)/.1 AT B1
IS THIS THE 1ST TIME THROUGH?
YES
NO
IS QT' GREATER THAN .05? (WAS THERE A LOT OF NOISE THIS TIME)
NO
YES
MAGNIFY QT' BY FORMING
QT = 9QT' - .4
TO MINIMIZE HEIGHT OF STATION BURSTS NOW
S46
0013
S50
LOOK FOR PREVIOUS QT LARGE INDICATING THAT THERE WAS A LOT OF NOISE BEFORE
IS QT GREATER THAN .05?
NO
S49
0013
YES
S48
SET OLD QT = .025 SO THAT NEW QT CAN DROP SHARPLY SINCE QT' IS NOW SMALL

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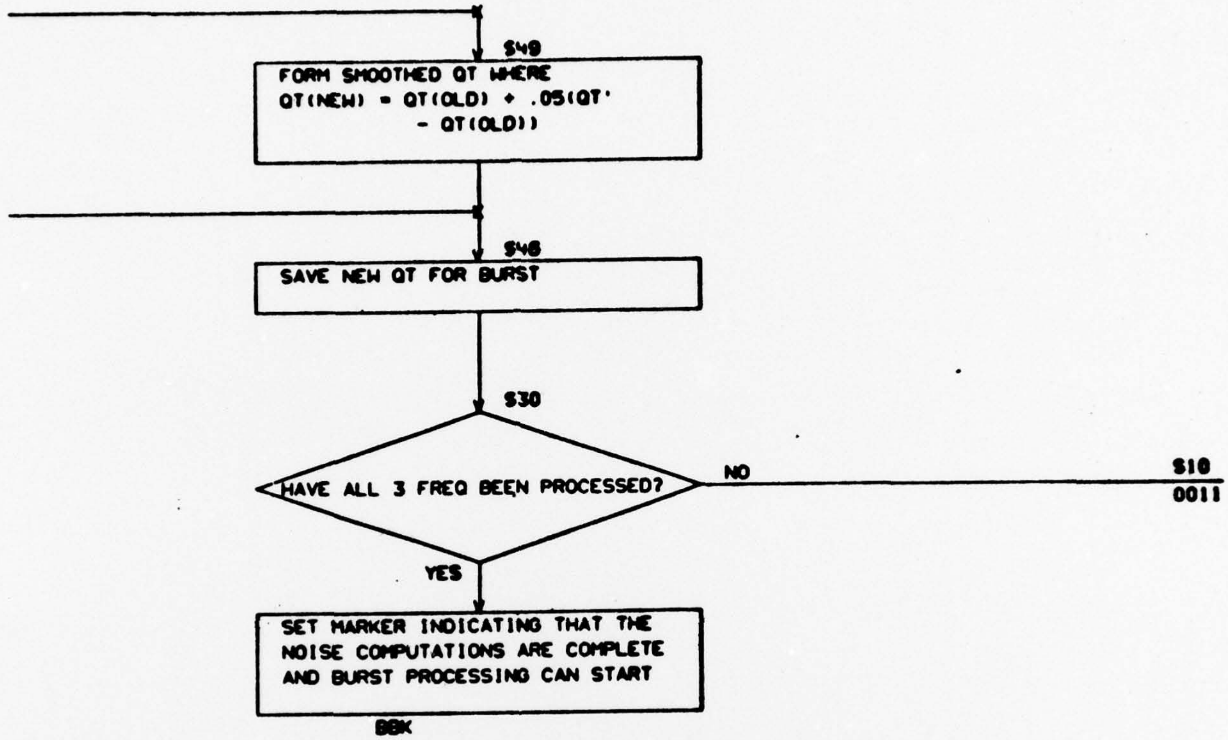
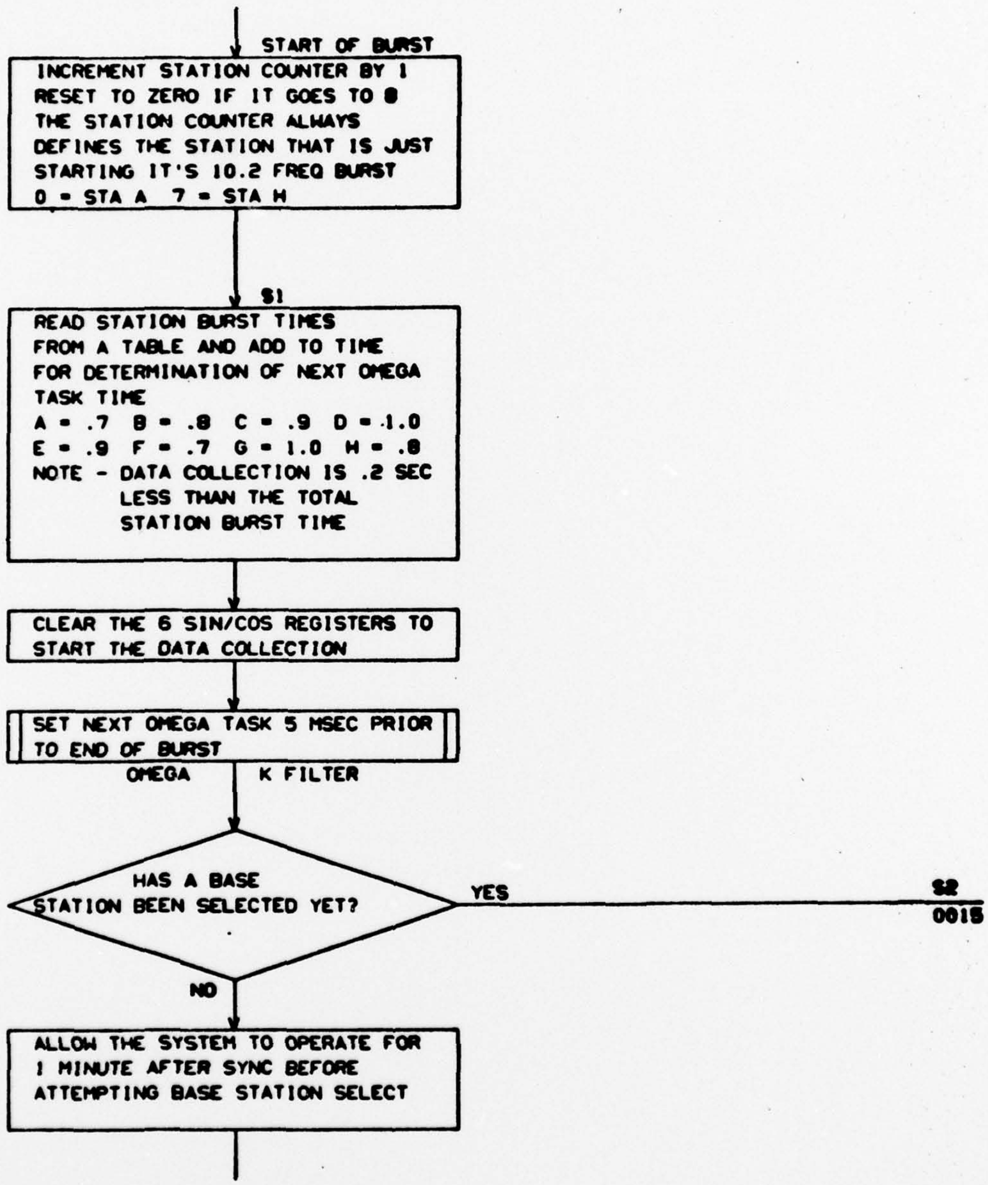
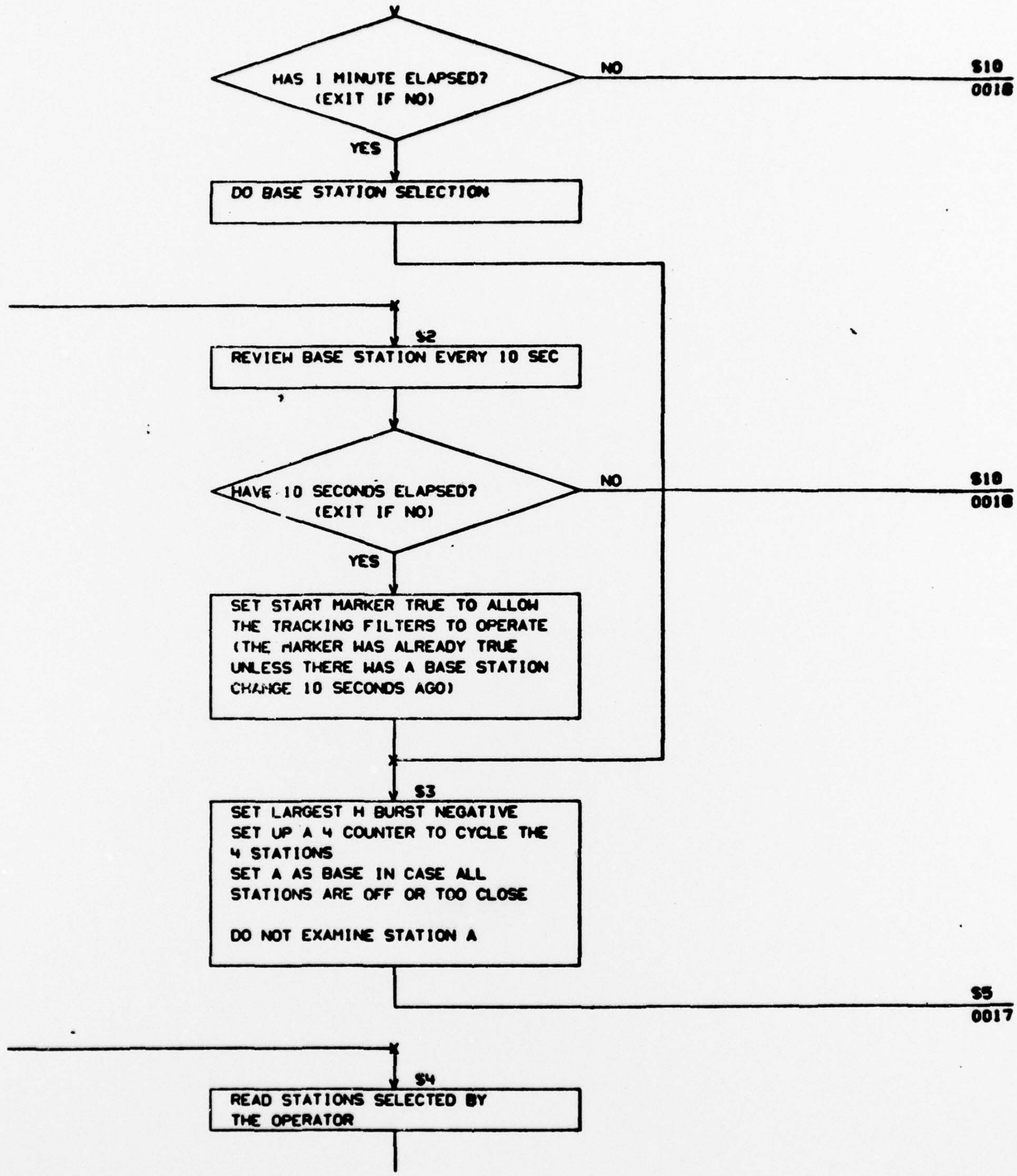
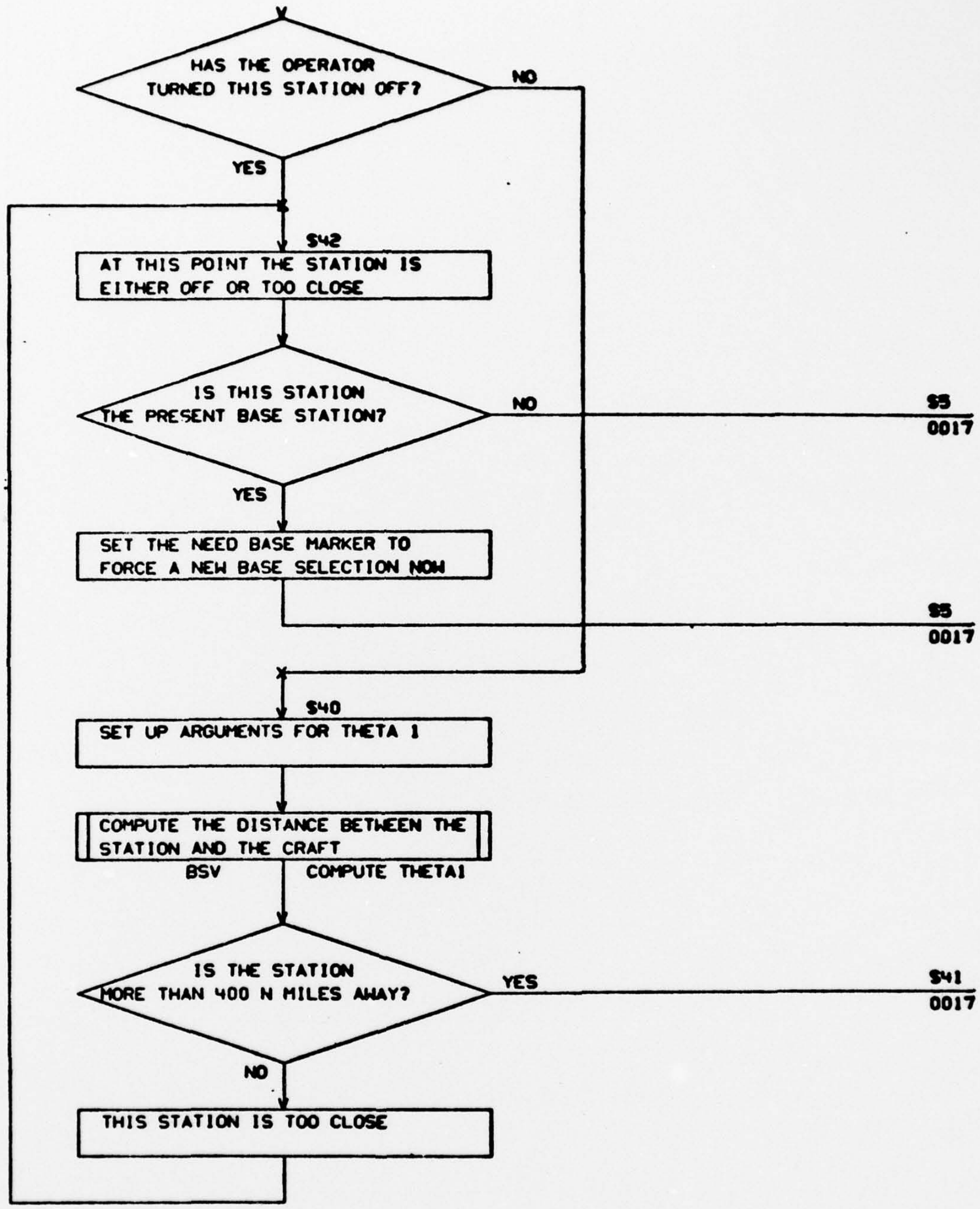
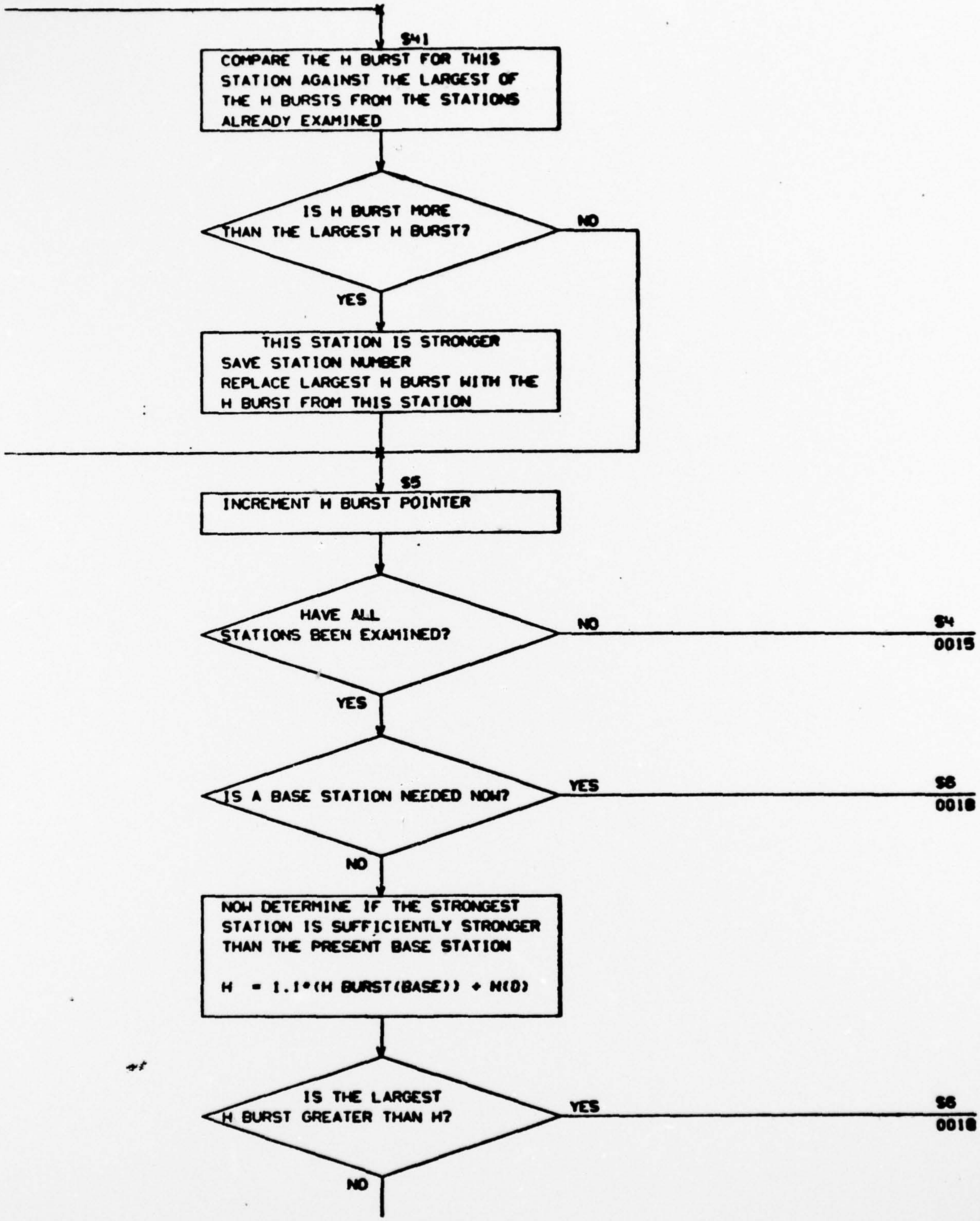

S49
FORM SMOOTHED QT WHERE
QT(NEW) = QT(OLD) + .05(QT'
- QT(OLD))
S46
SAVE NEW QT FOR BURST
S30
HAVE ALL 3 FREQ BEEN PROCESSED?
NO
S10
0011
YES
SET MARKER INDICATING THAT THE
NOISE COMPUTATIONS ARE COMPLETE
AND BURST PROCESSING CAN START
BBK

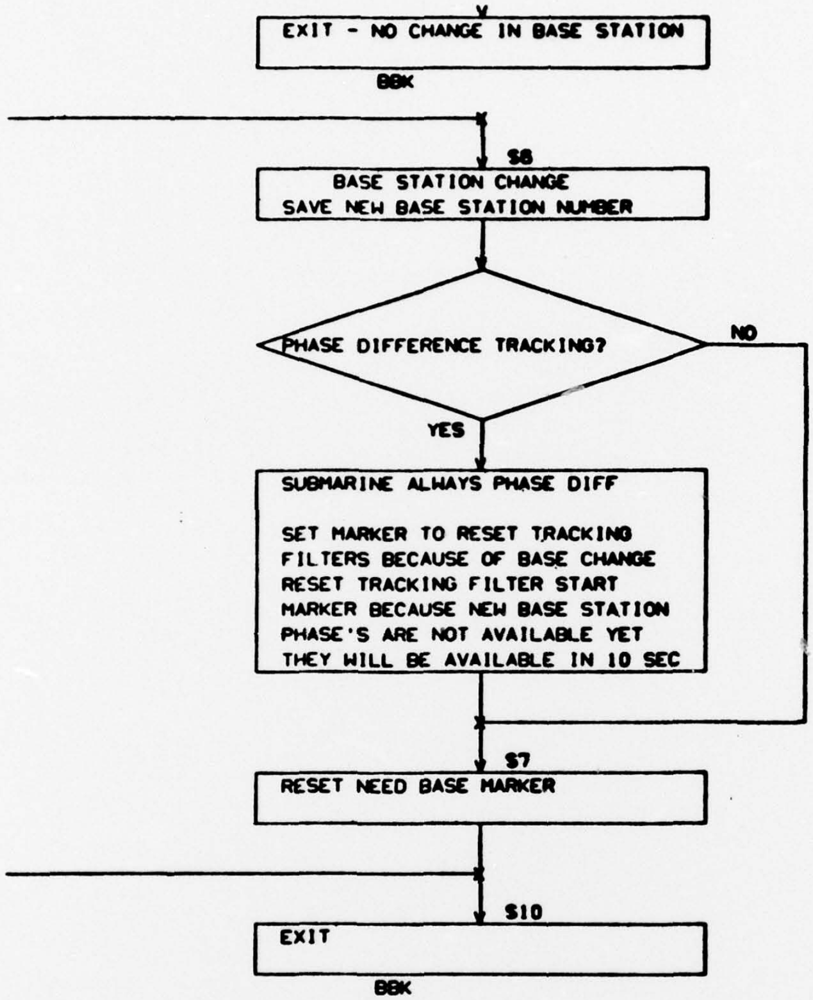
- START OF BURST
-
- THIS ROUTINE IS AN OMEGA TASK THAT IS EXECUTED AT THE START
- OF EACH STATION BURST DATA COLLECTION PERIOD. THE PROGRAM
- INCREMENTS THE STATION COUNTER, SETS THE TIME OF BURST AND
- PERFORMS BASE STATION SELECTION
-




HAS 1 MINUTE ELAPSED?
(EXIT IF NO)
NO
S10
0018
YES
DO BASE STATION SELECTION
S2
REVIEW BASE STATION EVERY 10 SEC
HAVE 10 SECONDS ELAPSED?
(EXIT IF NO)
NO
S10
0018
YES
SET START MARKER TRUE TO ALLOW THE TRACKING FILTERS TO OPERATE (THE MARKER WAS ALREADY TRUE UNLESS THERE WAS A BASE STATION CHANGE 10 SECONDS AGO)
S3
SET LARGEST H BURST NEGATIVE
SET UP A 4 COUNTER TO CYCLE THE 4 STATIONS
SET A AS BASE IN CASE ALL STATIONS ARE OFF OR TOO CLOSE
DO NOT EXAMINE STATION A
S5
0017
S4
READ STATIONS SELECTED BY THE OPERATOR


HAS THE OPERATOR TURNED THIS STATION OFF?
NO
YES
S42
AT THIS POINT THE STATION IS EITHER OFF OR TOO CLOSE
IS THIS STATION THE PRESENT BASE STATION?
NO
S5
0017
YES
SET THE NEED BASE MARKER TO FORCE A NEW BASE SELECTION NOW
S5
0017
S40
SET UP ARGUMENTS FOR THETA 1
COMPUTE THE DISTANCE BETWEEN THE STATION AND THE CRAFT
BSV
COMPUTE THETA1
IS THE STATION MORE THAN 400 N MILES AWAY?
YES
S41
0017
NO
THIS STATION IS TOO CLOSE


S41
COMPARE THE H BURST FOR THIS STATION AGAINST THE LARGEST OF THE H BURSTS FROM THE STATIONS ALREADY EXAMINED
IS H BURST MORE THAN THE LARGEST H BURST?
NO
YES
THIS STATION IS STRONGER
SAVE STATION NUMBER
REPLACE LARGEST H BURST WITH THE H BURST FROM THIS STATION
S5
INCREMENT H BURST POINTER
HAVE ALL STATIONS BEEN EXAMINED?
NO
S4
0015
YES
IS A BASE STATION NEEDED NOW?
YES
S6
0018
NO
NOW DETERMINE IF THE STRONGEST STATION IS SUFFICIENTLY STRONGER THAN THE PRESENT BASE STATION
H = 1.1*(H BURST(BASE)) + H(0)
IS THE LARGEST H BURST GREATER THAN H?
YES
S6
0018
NO


EXIT - NO CHANGE IN BASE STATION
BBK
S8
BASE STATION CHANGE
SAVE NEW BASE STATION NUMBER
PHASE DIFFERENCE TRACKING?
NO
YES
SUBMARINE ALWAYS PHASE DIFF
SET MARKER TO RESET TRACKING
FILTERS BECAUSE OF BASE CHANGE
RESET TRACKING FILTER START
MARKER BECAUSE NEW BASE STATION
PHASE'S ARE NOT AVAILABLE YET
THEY WILL BE AVAILABLE IN 10 SEC
S7
RESET NEED BASE MARKER
S10
EXIT
BBK

3.3 COMPUTER SUBPROGRAM ENVIRONMENT

3.3.1 OMEGA Processing Tables

a) END BURST:

Antenna Slot Time Table: This table is used to select the appropriate signal to be monitored during the following slot time when the loop antenna is in use. The table is described in detail in the flow charts (page 1) and in the listing. The official name of this table is ANTENNA NOISE CALIBRATE CODES.

b) END SLOT

Loop Antenna Table: This table is used to select the approrpiate antenna lobe for the station transmitting a particular frequency during the next burst time. The table is described in detail in the flow charts (page 7) and in the listing. Note that the sign bit is set to define the minus condition. The official name of this table is ANTENNA SELECT TABLE.

Floater Antenna Table: This table is used to select the appropriate antenna lobe for the station transmitting a particular frequency during the next burst time when the Floater antenna is in use. The table is described in detail in the flow charts (page 7) and in the listing. Note that the sign bit is set to define the minus condition. The official name of this table is FLOATER SELECT TABLE.

c) START BURST

Station Burst Pattern: This table is used to determine the burst time for each station. The table is defined in detail in the flow charts (page 14) and the listing. The resolution for the burst times is 0.005 seconds. The official name of this table is STATION BURST TIMES.

Station Locations: This table contains the location of all existing OMEGA transmitting stations. Each location is specified in a three element geocentric position vector. The first entry is for Station A. The table is defined in detail in the history. The official name of this table is STATION VECTOR TABLE.

3.3.2 OMEGA Processing Temporary Storage

All temporary storage used by the OMEGA Processing routine is in the R15 stack.